

DIFFERENCE IN MANIFESTATION OF THE WHITTEN EFFECT
AMONG dd-GROUP-STRAINS ESTABLISHED
FROM COMMON ANCESTOR, dd MICE

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Abstract

Strain difference in the Whitten effect was examined among 4 inbred strains (DDD, DDY, DSD and DDK) and a closed colony (ddY) belonging to the dd-group, which have been established from the common ancestor, so-called "dd mice" in Japan. Two to 4 virgin females were caged together with a male of the same strain at 60-90 days of age, and examined for copulation every morning for 10 days. The Whitten effect was evident in the DDD and ddY strains, copulation rates increased greatly on the 3rd night after male introduction. By contrast, the DSD and DDK strains showed no such effect, while about 30% of the DDY females mated on the 1st night. These findings appear to show wide differences in manifestation of the Whitten effect by females among the dd-group-strains. Strain difference among relational strains belonging to the dd-group seems to have been fixed genetically during intense inbreeding and non-inbred closed breeding which have been continued independently since the separation.

INTRODUCTION

It is a well-known fact that pheromones from the male influence reproductive cycles in the female mice, i. e., Lee-Boot effect, Bruce effect and Whitten effect.¹⁾ There are several reports to assert that the manifestation of the Bruce effect (exteroceptive block to pregnancy in mice) and the related pheromonal phenomena by females considerably differ among different strains of mice^{2,3,4,5,6,7,8)}. The authors reported the strain difference in manifestation of the Whitten effect (sincronization of estrous cycles in response to stimuli associated with male mice) by females among six inbred strains⁹⁾.

On the other hand, several inbred strains of mice (the dd-group-strains) have been established in Japan from the common ancestor, so-called "dd mice"

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which had been taken by Dr. S. Hata from Germany to the Kitasato Institute, Japan in 1920 or there about (dd = Deutschland-Densenbyo Kenkyusho)^{9,10,11,12,13,14}. Of the above dd-group-strains, the DDY and DDK strains were mentioned in the previous report and the existence of strain differences in manifestation of the Whitten effect by females among the dd-group-strains was suggested⁸.

In the present study, we will report strain differences in manifestation of the Whitten effect by females among relational strains belonging to the dd-group.

MATERIALS AND METHODS

Four inbred strains (DDD, DDY, DSD and DDK) and a noninbred closed colony (ddY) belonging to the dd-group were used in this study. All of these strains were established at respectively different institutes in Japan from the common ancestor "dd-mice" which had been maintained in the Institute of Infectious Diseases (the Institute of Medical Science at present), Tokyo University, Japan (Jms*)^{9,10,11,12,13,14}. The pedigree of the above dd-group-strains is summarily illustrated in Fig. 1. The DDK and DSD strains were introduced to the

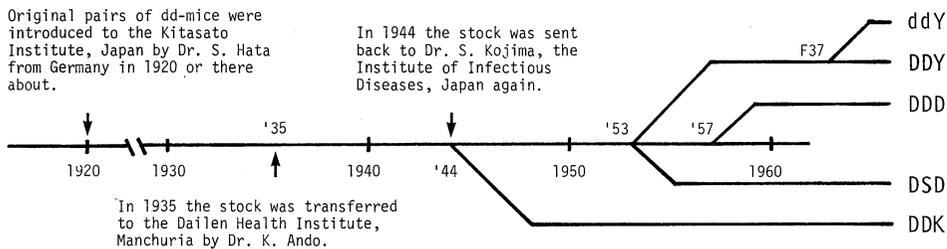


Fig. 1. Pedigree of 5 strains belonging to the dd-group, illustrated according to the references numbering 9-16.

Since 1944 the dd-stock had been maintained by non-inbred closed breeding in the Institute of Infectious Diseases, Japan until 1962. From the non-inbred dd-stock of Jms, the DDK, DDY, DSD and DDD strains had been separated in '44, '53, '53 and '57 respectively and brother × sister matings had been started simultaneously with the separation. The ddY had been separated from the DDY at the 37th generation of inbreeding in '63, since then it have been maintained as a closed colony.

Division of Laboratory Animal Science, National Institute of Animal Health, Japan (Jah*) in 1963 from Nagoya University (Nga*) and Tohoku University (Sda*) respectively, and the DDD and DDY strains were introduced in 1969 from Jms and the National Institute of Health (Yok*) respectively. Since then, these strains have been maintained as Jah sublines by brother × sister matings

* Abbreviations for use in symbolizing substrains being used in the standardized nomenclatures for inbred strains of mice^{9,10}.

in Jah¹⁸). The non-inbred ddY strain (closed colony originated from inbred strain) was introduced from Shizuoka Laboratory Animal Agr. Co. Associat. in 1972 and has been maintained by 25 × 25 rotation cross system as a closed colony in Jah.

Males and females were segregated at weaning (21-day-old) and housed in an air-conditioned room at approximately 25°C. They were fed Oriental compressed pellet diet (CMF) and provided with tap water *ad libitum*. Two to 4 virgin females were caged together in separate aluminum cages (20 × 30 × 10cm) with clean wood shavings and a male of the same strain was introduced to each cage at 60 to 90 days of age. The copulation was checked by the occurrence of vaginal plug daily in the morning for 10 days after the male introduction.

Significance of strain difference among the dd-group-strains was statistically tested by the χ^2 -test.

RESULTS AND DISCUSSION

The cumulative copulation rate within 10 days after the male introduction varied considerably among the different dd-group-strains from 58.4% in the DDK to 95.8% in the ddY as shown in Table 1 and Fig. 2. Strain difference in the cumulative and the daily copulation rates were mostly statistically significant (Table 2). In Fig. 3, the daily incidence of copulation observed in five

TABLE 1. Daily and cumulative copulation rates after male introduction in dd-group mouse strains

Strain	No. of animals	Copulation rates on each of 10 days after male introduction (%)											Cumulated
		1	2	3	4	5	6	7	8	9	10		
ddY	692	17.2	14.0	36.4	12.7	3.0	2.4	3.7	1.1	0.7	0.8	95.8	
DDD	511	16.4	13.5	33.4	11.3	0.3	2.1	6.0	2.5	0.3	0.9	87.4	
DDY	341	29.6	4.9	9.6	6.4	4.1	5.8	6.4	2.3	1.7	1.1	72.4	
DSD	363	25.0	16.2	20.6	7.7	0.5	5.2	7.1	2.4	0.8	1.6	87.6	
DDK	291	12.7	4.7	11.3	8.1	5.8	3.0	2.4	2.7	2.7	4.4	58.4	

TABLE 2. Summary of significance level for strain differences in copulation rates tested by χ^2 -test in each of matched-pairs

cumulated					2nd night						
	DDK	DSD	DDY	DDD	ddY		DDK	DSD	DDY	DDD	ddY
ddY	***	***	***	***	ddY	ddY	***	n.s	***	n.s	ddY
DDD	***	n.s	***	n.s	DDD	DDD	***	n.s	***	n.s	DDD
DDY	***	***	***	***	DDY	DDY	***	***	***	***	DDY
DSD	***	n.s	**	**	DSD	DSD	***	n.s	***	***	DSD
DDK	***	***	n.s	*	DDK	DDK	***	***	***	***	DDK

1st night

3rd night

*** : $p < 0.001$, ** : $0.001 < p < 0.01$, * : $0.01 < p < 0.05$, n.s : $0.05 < p$

strains clearly shows the existence of strain difference in manifestation of the Whitten effect by females among the dd-group-strains. In the ddY, DDD and DSD strains, about 15 to 20% of females mated on each of the first two nights. More than 30% of females then mated on the third night after the male introduction in the ddY and DDD. The females of these two strains strongly manifested the Whitten effect. Whereas only 20%, even amount with the first two nights, of the DSD females mated on the third night and the Whitten effect could not be observed in this strain. Contrasted with other 4

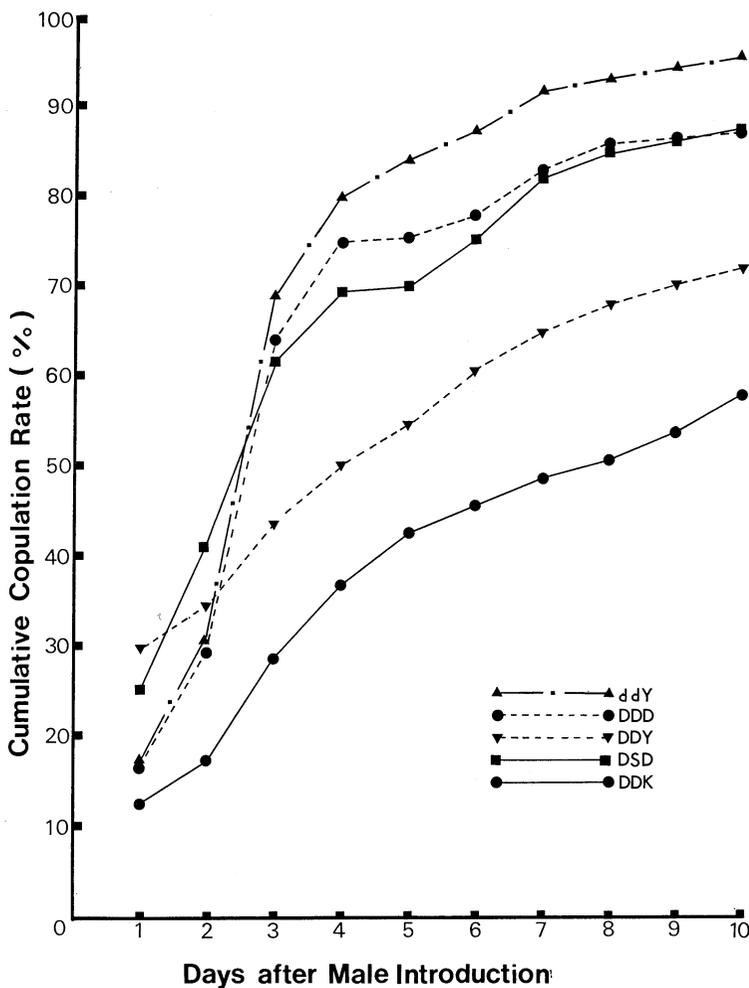


Fig. 2. Cumulative copulation rate within ten days after male introduction in the dd-group-strains.

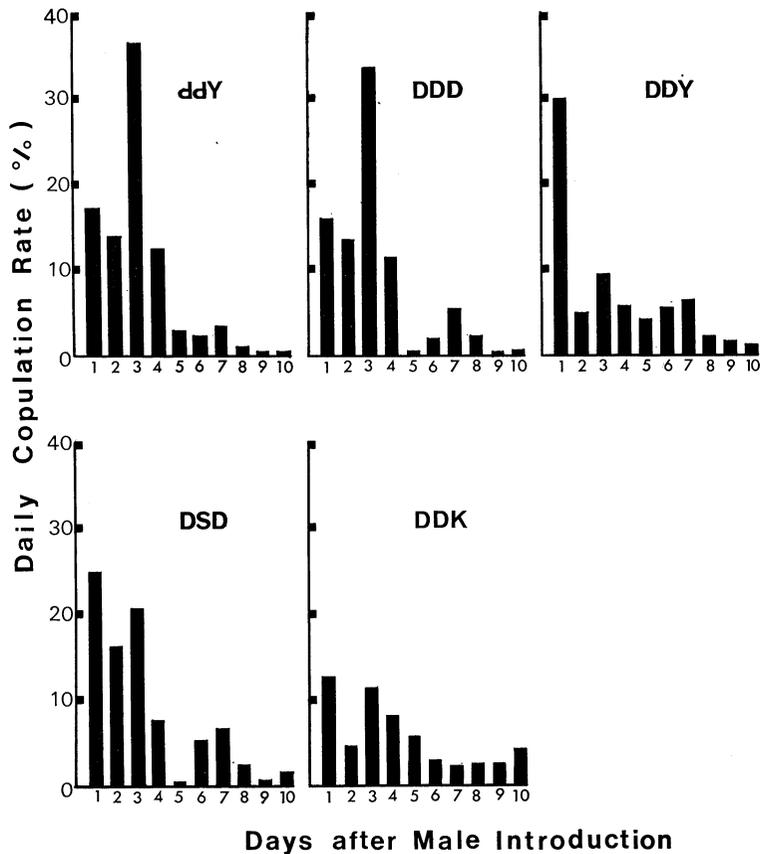


Fig. 3. Incidence of copulations on each of ten days after male introduction in the dd-group-strains.

strains, about 30% of the DDY females mated on the first night and no further peak of the daily incidence of copulation was observed afterwards. The daily incidence of copulation stayed at a low level in the DDK strain throughout ten days, but slightly increased on the third and fourth nights, 11.3% and 8.1% respectively.

These findings indicate the existence of notable strain difference in manifestation of the Whitten effect by female mice in agreement with those of Krzanowska⁶, Whitten³ and Kita et al⁸. It is, however, strange why did the DDY females copulate on the first night at the high rate of about 30%, as mentioned in the previous report⁸.

There are many reports to assert that the manifestation of the pheromonal phenomena by females differs among different strains of mice^{2,3,4,5,6,7,8}.

Such studies with numerous inbred strains demonstrate that genetically determined variation of intensity of male odorous substances and pheromonal sensitivity of females occurs within the species *Mus musculus*²⁾. In most of these reports, strains in distant relation which had been established from respectively different original stocks were used to survey the strain difference except that of Krzanowska. It is a well-known fact that numerous characteristics differ among different strains of mice in distant relation which had been established from different origins and among relational strains which had been separated selectively from a common origin^{19,20)}. On the other hand, the groups of relational inbred strains established from common ancestor without artificial or deliberate selection, as the dd-group-strains, are also believed to have similar characteristics. The present data, however, demonstrate the notable strain difference existing among the relational dd-group-strains established without artificial or deliberate selection from the non-inbred dd mice which had been maintained in Jms. There is a substantial agreement between Nishida and Inaba's results¹⁷⁾ and the present results concerning the existence of strain difference among the dd-group-strains. Furthermore Nagasawa et al.²¹⁾ have noted the existence of strain difference in mammary traits between the DSD and the DDD strains.

These strain differences among the dd-group-strains seem to have been genetically fixed during intense inbreeding and non-inbred closed breeding which have been continued independently since the separation. And the factors producing such strain difference may be the natural selection being influenced by unconscious artificial selection, the random drifting of genes and the depressing effect of continuous inbreeding²²⁾.

ACKNOWLEDGMENT

We thank Dr. Shigetaka Shibata (Director, National Institute of Animal Health, Tokyo) for providing the research facilities during this study, and the late Mr. Gosuke Suzuki and Mr. Saburo Hashimoto for their self-sacrificing assistance on taking care of experimental animals. We are also grateful to Masanobu Gang for helpful discussion.

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